Analysis of the change in mineral dust optical properties over the Eastern Mediterranean with source location using SEAWIFS imagery

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Abstract **Mineral dust from surrounding arid regions is the major aerosol in the Mediterranean atmosphere during spring and summer. The Eastern Mediterranean is particularly interesting because mineral dust may come from three different sources, originate from the central Sahara in spring, the eastern Sahara in summer and the Middle East/Arabian peninsula in autumn. We obtain the best agreement between SeaWiFS and Sun-Photometer derived aerosol optical thickness by considering the opt ical properties dust transported from different sources.**

Dust optical properties over the Eastern Mediterranean can be separated in two main categories with different absorption efficiencies. By using the TOMS absorbing aerosol product to locate the dust sources, we found that mineral dust that comes from Middle East Arabian Peninsula has lower absorption in blue and green parts of the solar spectrum than dust coming from Sahara. In addition, we found that the dust coming from Sahara over the Eastern Mediterranean has optical properties similar to that transported over the Atlantic. This new set of mineral dust optical properties will be used to improve ocean color estimates in the Eastern Mediterranean Sea.

Keywords-aerosol;mineral dust;refractive index

I. INTRODUCTION

Saharan dust plumes are the major source of terrigeneous material in the atmosphere of the Mediterranean Sea and North Atlantic Ocean, and they also influence the chemistry and biology of the water column. The optical properties of these mineral particles still remain poorly known. The most striking and unknown characteristic of mineral dust in the solar spectrum is its ability to absorb in the violet, blue, and green portions of the spectrum (400-500 nm). Moreover, this absorption, characterizedby the imaginary part of the refractive index (the absorption index) of dust particles, is potentially highly variable since it depends on the amount of iron oxides (mainly hematite) Sokolik et al., 1993; Claquin et al., 1999] in the originating soil. Mineral dust constitutes an extreme case in atmospheric correction of ocean color because it often combines very high optical depths with a strong absorption capacity in the blue [Patterson, 1981].

The present study uses continuous surface-based sun photometer ground-based aerosol optical measurements measurements at the IMS-METU site at Erdemli (36° 33' N, 34°15' E) along the Turkish coast of the northeastern Mediterranean from January 2000 to June 2001 The data are conducted within the framework of the Aerosol Robotic Network (AERONET) program. The measurements are used to identify major characteristic features of mineral dust optical properties. All these aerosol optical data from the region, when pooled together, ultimately serve a basis for improving regional dust correction algorithm [Moulin et al., 2001a,b].

II RESULTS

DATA SELECTION AND PROCESSING

In this work, we used the method of Moulin et al. [2001] to estimate dust optical properties (including absorption) over the Eastern Mediterranean from SeaWiFS spectral measurements.Briefly, a set of N candidate aerosol models is used along with a model of water-leaving radiance. In this context, an aerosol model is comprised of a particle size distribution and index of refraction, with the radiative properties computed using mie theory and a vertical distribution of aerosol We applied the SMA (Gordon et al. 1997) to SeaWiFs on a pixel-by-pixel basis. We selected the most intense springtime and summertime dust events that occured in 2000. For pixels with high optical thickness (> 1), we assumed that the marine contribution to the SeaWiFS measurement is negligible in the visible, so that the measured reflectance spectrum is solely due to aerosol and molecular scattering. After molecular scattering removal, we computed aerosol reflectances for various dust absorbing efficiencies until these modeled reflectances match the measured ones. Comparisons between in_situ AOD showed that the Atlantic models created by Moulin (Moulin at al. 2001,a) using Shettle and Fenn 1979 , refractive index and size distribution values are close to the observations if the dust is Sahara origin. These models fails if dust transported from the Middle East. We used Sun Photometer refractive index and Size distribution retrivals to model Middle East dust.

SUN PHOMETER DATA

The aerosol optical measurement program recently initiated at a coastal rural site (IMS-METU-Erdemli) has provided a better understanding of dust optical characteristics in the northeastern Mediterranean. The study period extends from January 2000 to June 2001, and is characterized by frequent dust outbreaks from different sources around the region; mineral dust is therefore responsible for most of the variability in the aerosol optical properties.

In addition to drastic increase in aerosol optical thickness up to 1.8, the dust episodes are characterized by a sharp drop in Angstrom coefficient to values near zero, high scattering with single scattering albedo greater than 0.95 and the real part of the refractive index around 1.5±0.5, lower absorption given by the imaginary part of the refractive index less than 0.002, and an almost neutral spectral dependence of these parameters. Dust particles possess a bimodal size distribution with typical volume mean radii 2.2 μm and 0.08 μm for coarse and fine size fractions, respectively, and the corresponding volume concentrations of about 1.0 and 0.1 $\mu m^3\ \mu m^{-2}$ of dust particles. The Saharan and Middle East desert dusts differ by their absorption index values 0.0015 and 0.0005, respectively, due possibly to differences in their minerology.

DUST SOURCES

We combined aerosol observations of TOMS and Seawifs to investigate the sources of Saharan dust transport over the Mediterrenean. TOMS derived Aerosol index (AI) is a semi-quantitative product, but available over both oceanic and continental regions. For the TOMS/Nimbus-7 instrument, the AI was determined using the 340 and 380-nm bands. Briefly, the AI was relies on the spectral attenuation of the Rayleigh scattering due to aerosol absorption. The AI is defined so that the positive values generally correspond to UV-absorbing aerosols (eg., desert dust and carbonaceous particles) and negative values correspond to non-absorbing aerosols (e.g., desert sulfate aerosols).

In order to illustrate in more detail impacts of dust outbreaks from distinctly diffferent sources on the eastern Mediterranean aerosol optical properties, three particular dust intrusion events are examined below. The one occured in April 2000 represents the case of intense dust transport from the Sahara desert. The October 2000 dust event provides an example for a moderately strong dust intrusion mobilized from the Middle East-Arabian peninsula. The August 2000 case, on the other hand, reflects a temporal accumulation of more heterogeneous aerosol structure at the measurement site formed by combination of the Saharan and the Middle East dust inputs as well as urban-industrial aerosol supply from the north over Balkans, Ukraine and Anatolia. These three events are characterized by the most pronounced daily aerosol optical thickness peaks for the year 2000.

III. CONCLUSIONS

The validation of SMA to retrieve desert dust optical thickness over seawater from SeaWiFS data has been made by comparison with Sun Photometer data. We first develop a model resembling dust transported from Middle East/Arabian Peninsula. We showed that models suitable for the Saharan dust are not suitable for dust originated from nearby Middle East.

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REFERENCES

[1] Claquin, T., M. Schulz, and Y. J. Balkanski, Modeling the mineralogy of atmospheric dust sources, J. Geophys. Res., 104, 22,243-22,256, 1999.

[2] Gordon, H. R, T. Du, and T. Zhang, Remote sensing ocean color and aerosol properties: Resolving the issue of aerosol absorption, Appl. Opt., 36, 8670-8684, 1997.

[3] Moulin, C., H. R. Gordon, V. F. Banzon and R. H. Evans, Assessment of Saharan dust absorption in the visible from SeaWIFS imagery, J. Geophys. Res., 106, 18239-18249, 2001a.

[4] Moulin, C., H. R. Gordon, R. M. Chomko, V. F. Banzon and R. H. Evans., Atmospheric correction of ocean color imagery through thick layers of Saharan dust, Geophys. Res. Let., 28, 5-8, 2001b.

[5] Patterson, E. M., Optical properties of crustal aerosol: Relation to chemical and physical characteristics, J. Geophys. Res., 86, 3236-3246, 1981.

[6] Shettle, E. P., and R. W. Fenn, Models for the aerosols of the loweratmosphere and the effects of humidity variations on their optical properties, AFGL-TR-79-0214, Air Force Geophy. Lab., Hanscomb, AFB, Mass., 1979.